THURSDAY, APRIL 23, 1885

THE "CHALLENGER" EXPEDITION

Report on the Stalked Crinoidea Collected during the "Challenger" Expedition. By P. Herbert Carpenter, M.A., D.Sc. 4to, pp. 440, with 69 Plates. (London: Printed for Her Majesty's Stationery Office.)

"THE Stalked Crinoids," says Mr. Murray in his prefatory notice to this Report, "both on account of their rarity and their palæontological relations, are perhaps the most interesting and remarkable of deep-sea animals, and have been in a special manner associated with the *Challenger* Expedition. The joint work of the late Sir C. Wyville Thomson and Dr. W. B. Carpenter, first on *Comatula* and afterwards on *Pentacrinus*, together with the discovery by Prof. G. O. Sars of *Rhizocrinus* off the Lofoten Islands in 1864, led directly to the expeditions of the *Lightning* and the *Porcupine* in 1868 and the following years; and was thus indirectly concerned in the despatch of the *Challenger* Expedition in 1872." Not only for these reasons, but also on account of the exceptional value of Dr. P. H. Carpenter's Report, we shall give it a full notice.

Every scientific Palæontologist regards the group of *Crinoidea* with special interest. Not only do its fossilized skeletons present themselves—frequently in a state of admirable preservation—in almost all marine limestones from the Lower Silurian to the present time; but they are not unfrequently found to furnish by their accumulation no inconsiderable proportion of the calcareous material of such formations. And in the course of this long succession they exhibit a number of remarkable changes of type, each characteristic of a particular epoch. The most singular errors formerly prevailed respecting their zoological relations; and it was not until the publication in 1821 of the "Natural History of the *Crinoidea*," by J. S. Miller, a German naturalist residing in Bristol, that any successful attempt was made to systematise the group, by showing the true relation of its diversified forms to each other and to existing types. Miller was acute enough to recognise the close resemblance in the skeleton of the Liassic Crinoids first differentiated by him as *Pentacrini*—not only to that of a stalked Crinoid still living in the West Indian seas (which he described under the name of *Pentacrinus caput Medusæ*), but also to the unstalked *Comatula* of our own shores, which had been previously ranked with *Euryale* as an Ophiurid; and taking this as his point of departure, he worked out the morphology of the other fossil Crinoids then known, with a success which has rendered his Monograph the foundation of all that has been since done for the systematic arrangement of the multitudinous extinct forms which palæontological research is continually bringing to light. His recognition of the Crinoidal character of *Comatula* was afterwards fully confirmed by the discovery, made in 1836 by Mr. J. V. Thompson of Cork, that *Comatula* passes the earlier part of its life in the attached condition as a Pentacrinoid; dropping off its stem at a certain stage of its growth, and thenceforth remaining free.

The "epoch-making" monograph of J. S. Miller was followed in 1834 by the now classical Memoir of Joh. Müller, of Berlin, "Ueber den Bau des *Pentacrinus-caput Medusæ*"; of which recent type the soft parts were then for the first time described. The material for this description was chiefly furnished by a single spirit-specimen of the West Indian *Pentacrinus;* but as this wanted its visceral mass, the description of that part was supplied from *Comatula*, the structure of whose arms and ventral disk was found to conform very closely to that of the same parts in *Pentacrinus*. Müller completely reformed the nomenclature of his predecessor; and his designations of the several pieces of the Crinoid skeleton are now adopted by all writers on the group. And as, in addition, he was the first to give an account (although in several respects an erroneous one) of the nutritive and reproductive apparatus of the Crinoids, his memoir constitutes, as it were, the basement-story of the edifice whose foundation had been laid by J. S. Miller.

This was afterwards further built upon by Prof. Wyville Thomson and Dr. W. B. Carpenter; who, seeing that a thorough study of the entire life-history of *Comatula* would be likely to furnish a key to that of the extinct Crinoids, agreed to prosecute it conjointly: the former undertaking the earliest stage, that of the free-swimming pro-embryo (whose existence had been made known by Busch, a pupil of Müller), up to the time of its first attachment by a calcareous stem; and the latter following the Pentacrinoid through the successive phases of its existence, to its detachment and subsequent full development into the free *Comatula*. The results of their researches, embodied in the successive communications made by them to the Royal Society, have not only shown how these creatures lived and moved, but have furnished (as they anticipated) valuable guidance to all subsequent investigators into the Palæontological history of the *Crinoidea*. And they have also served as the basis of the more minute anatomical inquiries of Ludwig, Greef, Perier, and Dr. P. Herbert Carpenter; which, prosecuted with every advantage afforded by improved methods of microscopic examination, have confirmed Dr. Carpenter's correction of several serious errors in Müller's anatomy; whilst his important determination, both anatomical and experimental, of the principal nervous system in *Crinoidea*, has been recently put beyond all doubt (though long contested as morphologically impossible) by the further experiments of Prof. A. M. Marshall and Dr. Jickeli (see p. 407 *et seq.* of Dr. P. H. Carpenter's Report).

Prof. G. O. Sars's discovery, in 1864, on a bottom of from 400-500 fathoms' depth, of the singular little stalked *Crinoid* to which he gave the name *Rhizocrinus lofotensis*, was followed by the discovery, in the *Porcupine* Expedition of 1869, of a new and delicate Crinoid belonging to the same family, named *Bathycrinus gracilis* by Wyville Thomson, who brought it up from 2435 fathoms' depth in the East Atlantic; a second species of *Rhizocrinus* being also met with. And in 1870 a fortunate haul made by the *Porcupine* in 800-900 fathoms off the coast of Portugal, brought up *twenty* specimens of a full-sized new species of *Pentacrinus*, called by Dr. Gwyn Jeffreys (who had charge of that cruise) *P. wyville-thomsoni*.

About the same period, the United States Coast Survey brought up both *Rhizocrinus lofotensis* and the second species, *R. rawsoni*, in the West Indian Seas; while Sir Rawson Rawson, Governor of Barbadoes, who had been interested in the work by Dr. Carpenter, obtained three specimens of the singular genus *Holopus* (previously known as a recent type by only a single specimen so imperfect that its crinoidal nature was doubted), and several *Pentacrini* belonging to species which had been previously obtained for Wyville Thomson by Mr. Damon's collectors in the same region.

This was the sum of our knowledge, alike of types and of localities, when the *Challenger* Expedition set forth in 1872. The collections made during her voyage, supplemented by those made in the West Indian area by the U.S.A. surveying-ship *Blake* (types of which were placed by Prof. A. Agassiz in the hands of Sir Wyville Thomson for description), and a few gatherings from other sources, now raise the total of existing generic forms to 6, and of species to no less than 32; at the same time demonstrating the very wide diffusion of the stalked Crinoids over the oceanic floor, and showing their bathymetric range to extend from depths of less than 100 fathoms to 2500. A large collection was also made by the *Challenger* of unstalked *Comatulidæ*, including the singular aberrant genus *Actinometra;* together with a single specimen (recently described by Dr. P. H. Carpenter[1] under the generic designation *Thaumatocrinus*) of an unstalked type which presents a most singular survival of Palæocrinoidal characters.

Finding, on his return from the *Challenger* Expedition in 1876, that Dr. P. Herbert Carpenter had been further prosecuting the study of the *Comatulidæ*, on the basis laid down by his father, Sir Wyville Thomson placed in his hands the whole *Challenger* collection of unstalked Crinoids, which included not less than 150 new species; keeping in his own charge the collection of stalked Crinoids (together with the types of the *Blake* collection), on which he intended himself to report. This intention, however, he did not live to fulfil; and on his untimely death in March, 1882, Mr. Murray requested Dr. P. H. Carpenter to undertake the stalked Crinoids also. Beyond naming (mostly without diagnoses) several new genera and species, and directing the execution of 28 plates, Sir Wyville Thomson had made no preparation whatever for his Report; and on his successor, therefore, almost the whole labour of its production has fallen. The result has fully justified Mr. Murray's selection; for we feel sure that in proportion to the previous knowledge possessed by any student of this Monograph, will be his admiration of the masterly skill with which the knowledge derived from the careful and thorough study of every existing type at present known is made to elucidate the structure and life-history of the extinct Crinoids; this being no less apparent in the case of the *Palæocrinoidea*, which differ most widely from existing forms, than in that of the *Neocrinoidea*, many of which are represented in our existing fauna by forms that differ from them only specifically. In this, his *opus magnum*, will be recognised that combination of a remarkable aptitude for the apprehension of details, with a philosophic grasp of his subject as a whole, by which Dr. P. H. Carpenter's previous contributions to its literature have been distinguished; making him equally at home in characterising a specific type, in working out the minutest features of its organisation, and in discussing the homologies of the *Crinoidea* with those of the other divisions of the great Echinoderm group. Whilst giving the fullest credit to his predecessors and contemporaries, he has endeavoured to determine every point for himself; frequently clearing up an obscurity, or satisfactorily settling a disputed question, by more extended research of his own. And where he has found his own inferences from the study of existing types to disagree with those of Palæontologists who had acquired a deserved reputation for their labours on the fossil Crinoids, he has set forth the grounds of their opinions, and his own reasons for dissenting from them, with impartial fairness. This is conspicuous in his discussion of the morphological relations between the *Neocrinoids* and the *Palæocrinoids;* as to certain points of which he is at issue with the highest authority upon the latter group, Mr. Charles Wachsmuth, of Burlington, Iowa, U.S., which locality seems its metropolis. "We have approached the subject," he says, "from different sides; but upon one point we are in complete accordance—viz. the desire to find out the truth."

The *first* division of the Report, extending to 185 quarto pages, is devoted to the Morphology and Natural History of the *Crinoidea* generally, treated under the following heads:—(1) The skeleton, with the modes of union of its component joints; (2) the stem and its appendages; (3) the calyx; (4) the rays; (5) the visceral mass; (6) the minute anatomy of the disk and arms; (7) the habits of recent Crinoids, and their parasites; (8) the geographical and bathymetrical distribution of the Crinoids; (9) the relation between the recent and the fossil Neocrinoids; and (10) the relations of the Neocrinoids to the Palæocrinoids. All these subjects are treated with a completeness which leaves nothing to be desired; rendering this portion of the work a most admirable Introduction to the study of the *Crinoidea* generally, without a thorough mastery of which no one can henceforth be qualified to discuss any portion of the group.

The *second* division commences with a discussion of the principles on which the Classification of the *Crinoidea* should be based; after which, every type of Stalked Crinoids at present known is fully described, and its relations discussed. A few of the most interesting additions to our previous knowledge will be briefly noticed as samples of their value.

The structure of the strangely aberrant *Holopus* in which the basal and radial plates are completely anchylosed into an asymmetrical tube-like calyx, fixed by an irregularly expanded base, while the arms are exceptionally massive—is elucidated as fully as the state of the specimens permitted; and it is shown that not only the Cretaceous *Cyathidium*, with the Liassic *Cotylecrinus* and *Eudesicrinus*, which had been previously referred to the family *Holopidæ*, but also the Upper Silurian *Edriocrinus* of Hall, are to be associated with it; so that the pedigree of this family seems more ancient than that of any other recent type at present known.

The new genus *Hyocrinus*, instituted by Wyville Thomson for a beautiful little deep-sea Crinoid bearing a superficial resemblance to *Rhizocrinus*, is shown by Dr. P. H. Carpenter to have distinctive characters of such a rank as to require being ranked as a type of a new family, which, while not specially related to any other Neocrinoid, presents important characters that connect it with the Palæocrinoids.

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[1] *Philosophical Transactions*, 1883, p. 919, and "Report," p. 370.

The *Bathycrinus* of Wyville Thomson, of which three species are now known, and the *Rhizocrinus* of Sars, of which the two species now known prove to have a wide geographical distribution, are next minutely described as members of the family *Bourgeticrinidæ* (De Loriol). This family represented in the Cretaceous and Tertiary epochs the much more highly developed *Apiocrinidæ* of the Jurassic; and there seems every probability that we can now correctly reconstruct the whole anatomy of the Pear Encrinite on the basis supplied by Ludwig's study of the soft parts of *Rhizocrinus*, and Dr. P. H. Carpenter's account of those of *Bathycrinus*.

We next come to *Pentacrinus*, the typical genus of the family *Pentacrinidæ*, as this is the typical family of the *Neocrinidea*. Every palæontologist is familiar with the extraordinary development of this family type in the Liassic period, as shown in the splendid slabs exhibited in our museums. The most remarkable species, as regards the length of its stem and the number of the component joints, is *Extracrinus subangularis;* fossil specimens of whose stem have been found to measure from 50 to 70 feet. The mode in which the new joints are added at the summit of this stem was studied by Quenstedt, as well as the fossilised condition of his specimens permitted; but Dr. W. B. Carpenter has been able to work it out more completely in the recent *Pentacrinus wyville-thomsoni;* and the excellent figures drawn by Mr. George West for the illustration of a monograph of that type which Dr. Carpenter formerly intended to produce, show every successive stage in the development of the segments intercalated at and near the summit of the stem, the gradual assumption by the intercalated segments of the characters of those with which they alternate, and the progressive change from a pentangular to a circular outline, as well as in their articulating surfaces, which both series finally undergo; thus making it clear that great care must be used in erecting new fossil species (as has been frequently done) upon the slender evidence of an inch or two of stem.

Of the genus *Pentacrinus*, the three species which had been obtained from West Indian Seas before the discovery of the European type, had been so variously named and so diversely described, that their synonymy seemed in a state of hopeless entanglement. By a careful comparison, however, of the best-authenticated specimens of each with the large number since collected, Dr. P. H. Carpenter has found himself able to clear up the confusion; this having partly arisen from the wide range of individual variation, especially in a character hitherto regarded as of fundamental importance—the completeness of the basal circlet, and its external conspicuousness, as well as in the number of arms to each ray. The first-known species, originally called *Isis asterias* by Linnæus, now proves to be the rarest; several of the Museum specimens which had been referred to it, being here shown to belong to the species first distinguished by Œrsted in 1856 as *P. mülleri.* Greatly exceeding both these in abundance, is the elegant species originally named *P. decorus* in 1864 by Wyville Thomson, who had obtained a specimen of it from Mr. Damon; the dredgings of the U.S.A. steamer *Blake* in the Caribbean Sea and the Gulf Stream Channel having brought it up *by the hundred*, so that, as Prof. Agassiz remarks, "we must have swept over actual forests of Pentacrini crowded together, much as we find the fossil Pentacrini on slabs." Another species, *P. blakei*, was dredged by the *Blake* at four stations in the Caribbean Sea; and neither of these four species has been met with elsewhere. Of the *P. wyville-thomsoni*, which first presented itself in the *Porcupine* dredging of 1870, thirty specimens were recently dredged by the *Talisman* (French) at a depth of 800 fathoms off Rochefort; but it was not anywhere met with by the *Challenger*, which, however, brought up a specimen of a beautiful new species, *P. maclearanus*, from the Tropical Atlantic, several specimens of two types respectively named *P. naresianus* and *P. alternicirrus*, from the Western Pacific, and a single mutilated specimen from the Japan Sea of a doubtful type, which, on account of the deficiency of calcareous material in its calyx, Dr. P. H. Carpenter provisionally names *P. mollis.* All these species appear to have but a limited geographical range; and this seems also to have been the case with the fossil species of the Lias, the British and Continental species being mostly different. These, too, have a limited geological range; no species occurring in all its three divisions, and only two out of the fifteen which are found in the middle and upper Lias of this country being common to those two divisions.

Of all the stalked Crinoids, it is *Pentacrinus* (as was seen by J. S. Miller) which bears the closest resemblance to the unattached *Comatula;* the chief difference being that the basals of the pentacrinoid larva are retained in the adult *Pentacrinus*, whilst they disappear externally in *Comatula*, inward prolongations of them coalescing to form the curious "rosette" first described by Dr. W. B. Carpenter. In regard to their mode of life, there seems really very little difference between these two types; for observation of the habits of living *Comatulæ* shows that they only perform their beautiful swimming movements in order to find a suitable base to which they can attach themselves by their dorsal cirri; whilst on the other hand it seems quite certain that the stalked *Pentacrini* are not unfrequently detached by the fracture of their stems just below one of its nodal joints, and that the cirri which spring from the latter then bend downwards and cling to any suitable attachment, just like the dorsal cirrhi of *Comatulæ.* The structure of the visceral disk as well as of the arms and pinnules of *Pentacrinus*, has been found by Dr. P. H. Carpenter to bear the closest similarity to that of the corresponding parts in *Comatula;* and while the five-chambered organ at the base of the calyx, from the walls of which the primary nerve-trunks radiate, is much smaller in *Pentacrinus* than in *Comatula* (its greater size in the latter being obviously related to the number of verticils of cirral nerve-cords it has to give off), a similar dilatation of the Crinoidal axis presents itself in each node of the stem, giving off from its exterior a single such verticil.

It is not a little curious that in the Eastern Archipelago and the neighbouring part of the Pacific, *Pentacrinus* is replaced by a new generic type, closely allied to it in the most essential features of its structure, to which Sir

Wyville Thomson assigned the name *Metacrinus*, though without defining its distinctive characters. No fewer than eleven species of this genus were dredged by the *Challenger;* and, previously to his receiving this collection, Dr. P. H. Carpenter had come to the knowledge of three other species, a description of which he has communicated to the Linnæan Society. All these seem very limited in their geographical range, and not one of them has been found in the Atlantic. No fossil representative of this genus is at present known; but it is by no means impossible that some of the Liassic (reputed) *Pentacrini* may prove to belong to it.

In addition to the 28 plates drawn for Sir Wyville Thomson, and 5 of *Pentacrinus wyville-thomsonii* supplied by Dr. W. B. Carpenter, 35 plates have been drawn under Dr. P. H. Carpenter's direction, many of them containing numerous figures; while another has been autotyped from micro-photographs prepared by himself; making a total of 69 plates, for the most part admirably executed, besides 21 woodcuts in the text. When we add that the work is provided with a copious bibliography and an excellent index, we hope that we shall have made it clear that nothing, in our judgment, is wanting to its completeness.—The report on the *Comatulidæ*, of which the preparation was far advanced before it was put aside for that on the stalked Crinoids, will, we trust, speedily follow. We shall next look for the monograph of the *Blastoidea*, on which, it is understood, Dr. P. H. Carpenter has been for some time engaged, in conjunction with Mr. R. Etherege, jun., and which will, we believe, throw an altogether new light on that most interesting group. And every British Palæontologist, we feel sure, will desire that he may then find himself enabled to undertake, on the sure basis he has now laid, a complete review of the Fossil *Crinoidea* and a re-investigation of the little-understood *Cystidea*.

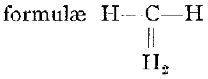
FRANKLAND AND JAPP'S INORGANIC CHEMISTRY

Inorganic Chemistry. By Edward Frankland, Ph.D., D.C.L., LL.D., F.R.S., Professor of Chemistry in the Normal School of Science; and Francis R. Japp, M.A., Ph.D., F.I.C., Assistant Professor of Chemistry in the Normal School of Science. (London: J. and A. Churchill, 1884.)

WHEN one opens a new book on Chemistry written by men who are generally recognised to be masters of their subject, one expects to find some light thrown on the great and confused heap of details with which one is accustomed to be confronted in the pages of the ordinary chemical text-book.

Hydrogen, it is true, can scarcely be expected to have changed its properties since the last treatise on descriptive chemistry was published; it still remains "a colourless gas devoid of taste and smell"; it is still a fact that "owing to its lightness this gas may be collected in inverted vessels by upward displacement." No one will venture to dispute the assertions that "in the free state hydrogen occurs in the gases of volcanoes (Bunsen)," or that "in combination hydrogen occurs in enormous quantities in water." But we have heard these statements so very often. Are they not preserved for us in the pages of scores of books, and of tens of scores of pamphlets? Surely it is not asking too much from our masters in chemistry that they should begin to make some use of the many facts which have been so laboriously collected. The "hewers of wood and drawers of water" have brought the materials into the camp: must they lie there for ever unused? They have been scheduled and catalogued a thousand times; was it necessary or advantageous that Profs. Frankland and Japp should undertake the work of issuing another catalogue?

The book before us contains 783 pages of printed matter; of these, 650 pages are devoted to descriptions of the elements and their compounds. One cannot expect much in this part of the book, except a repetition of the well-known facts. The formulæ in this book are perhaps a little more picturesque than usual; the judicious employment of thick type and small *o*'s, whether commendable or not from the chemical point of view, certainly gives an air of distinction to the page which the ordinary text-book is obliged to do without.

Turning to the introductory chapters, one is somewhat taken aback to learn on page 1 that cohesion, heat, light, gravity, chemical affinity, and electricity, are all forms of force. After learning this, one is certainly not surprised to be informed (pp. 64-5) that the formulæ  $H-\underset{H_2}{\underset{\|}{C}}-H$ and $O=C=o$, "give no indication that the molecule of the first compound contains a vast store of force, whilst the last is, comparatively, a powerless molecule." This confusion between force and energy is painfully visible throughout the book. Is there something radically absurd in the attempt to apply dynamical notions to chemistry? If not, why is it that when a chemist commits himself to a statement involving the conceptions force and energy in nine cases out of ten he gets altogether confused?

A great part of the advance made in chemistry in recent years is based on the adoption of clear and practical definitions of the atom and the molecule, and on the conceptions which flow from these definitions. Chapters IV., V., and VI. of Profs. Frankland and Japp's book deal with these subjects. Chapter IV. gives a clear and trustworthy account of the laws of chemical combination; Chapter V. deals with the atomic theory in an exceedingly satisfactory manner; and Chapter VI. presents us with a sketch of the methods whereby the molecular weights of gaseous elements and compounds, and the atomic weights of elements, are determined. These chapters appear to us to be especially good; a careful study of them is likely to be of much benefit to the student of chemistry. But if the student be of a critical turn of mind, he may object that he should be shown the "steep and thorny way," while the authors themselves, in the other parts of their book, "the primrose path of dalliance" tread. Thus, to take an instance, the molecular formula of ferric hydrate is given (p. 59, ***note***) as $Fe_2H_6O_6$; but ferric hydrate has never been gasified, and the theory of molecules as developed in Chapter VI. is a theory strictly applicable to gases only. Indeed, we might object to the incongruity between the teaching of Chapters V. and VI., and the practice of most of the book. These chapters define atom and molecule, and